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(54) **ROBOT JOINT DRIVING METHOD, COMPUTER-READABLE MEDIUM, DEVICE ASSEMBLY AND ROBOT HAVING THE SAME**

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B25J 17/02 (2006.01)
B25J 18/00 (2006.01)
B25J 9/10 (2006.01)

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USPC **74/490.04**; 74/490.01; 901/27

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See application file for complete search history.

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(57) **ABSTRACT**

Disclosed herein are a robot joint driving method, computer-readable medium, and device assembly which conducts motions similar to those of humans, and a robot having the same. These motions are achieved by arranging joint driving devices suited to characteristics of respective joints. The robot joint driving device assembly includes a tendon-type joint driving device using a wire, and a harmonic drive-type joint driving device using a gear reduction method. The tendon-type joint driving device is used to drive a rotary joint requiring high back-drivability, and the harmonic drive-type joint driving device is used to drive a rotary joint requiring high rigidity and high precision.

7 Claims, 13 Drawing Sheets

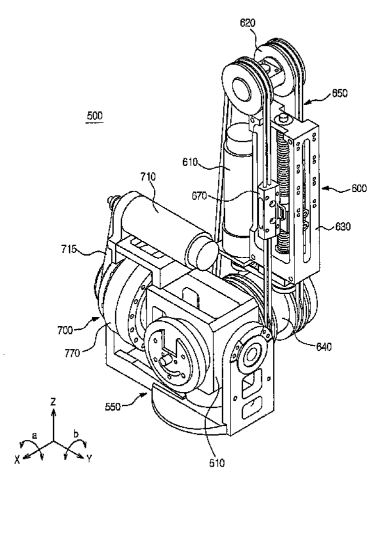

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FIG. 1

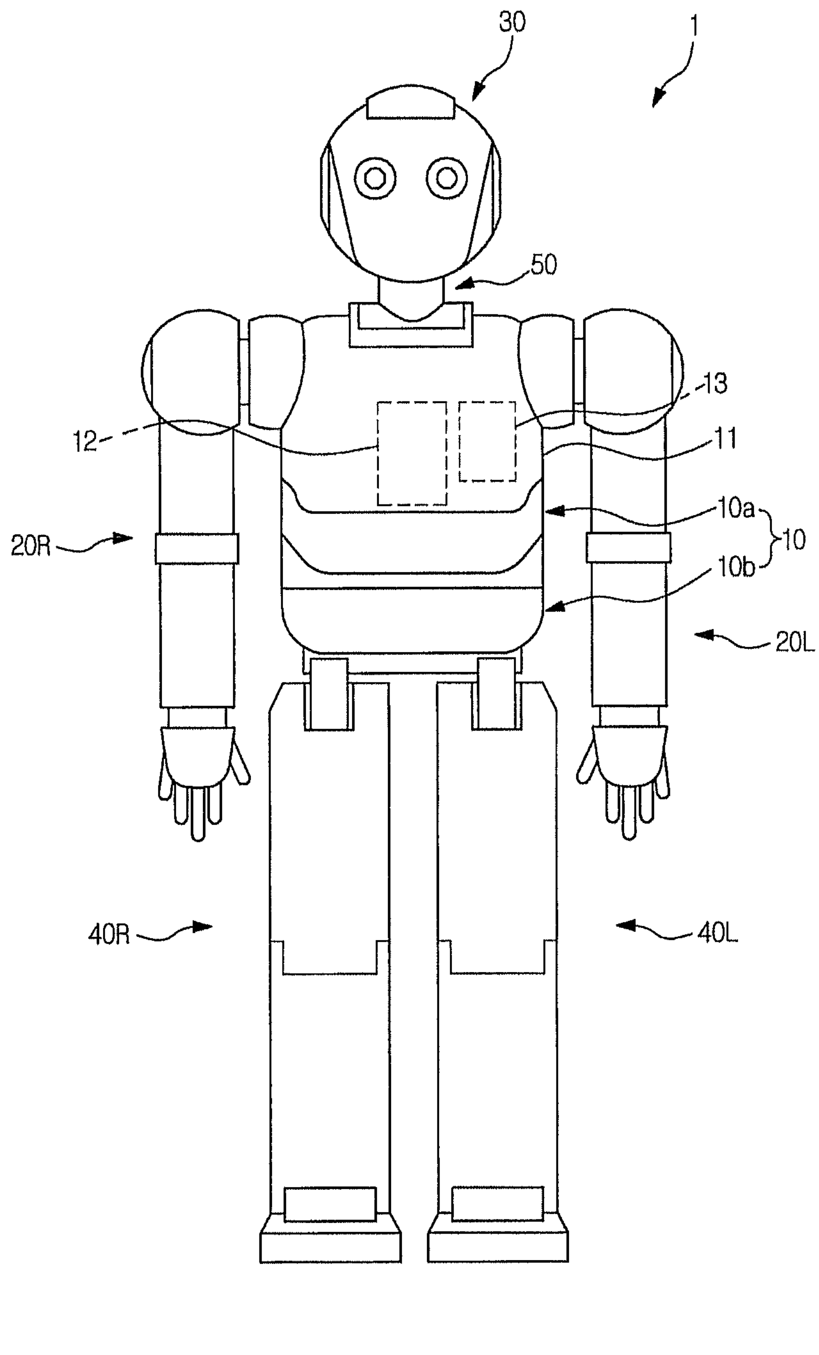
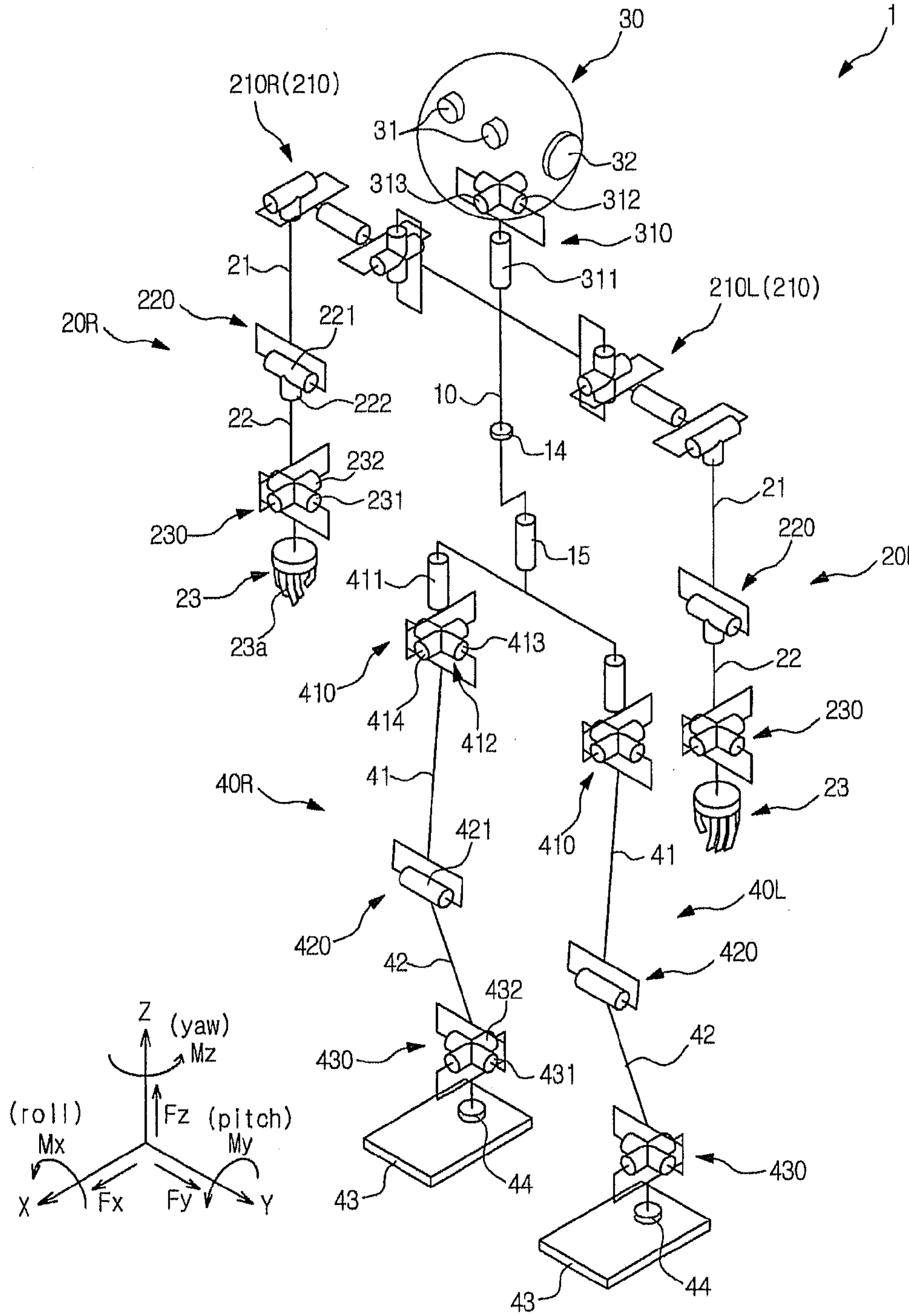


FIG. 2



30
1
210R(210)
31
32
313
312
310
311
21
210L(210)
220
221
20R
222
10
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14
232
231
21
230
15
220
20L
23
411
23a
413
410
22
414
412
230
40R
41
23
421
410
41
40L
420
420
42
432
42
Z
(yaw)
Mz
430
431
(roll)
Fz
(pitch)
Mx
My
430
X
Fx
Fy
Y
43
44
43
44

FIG. 3A

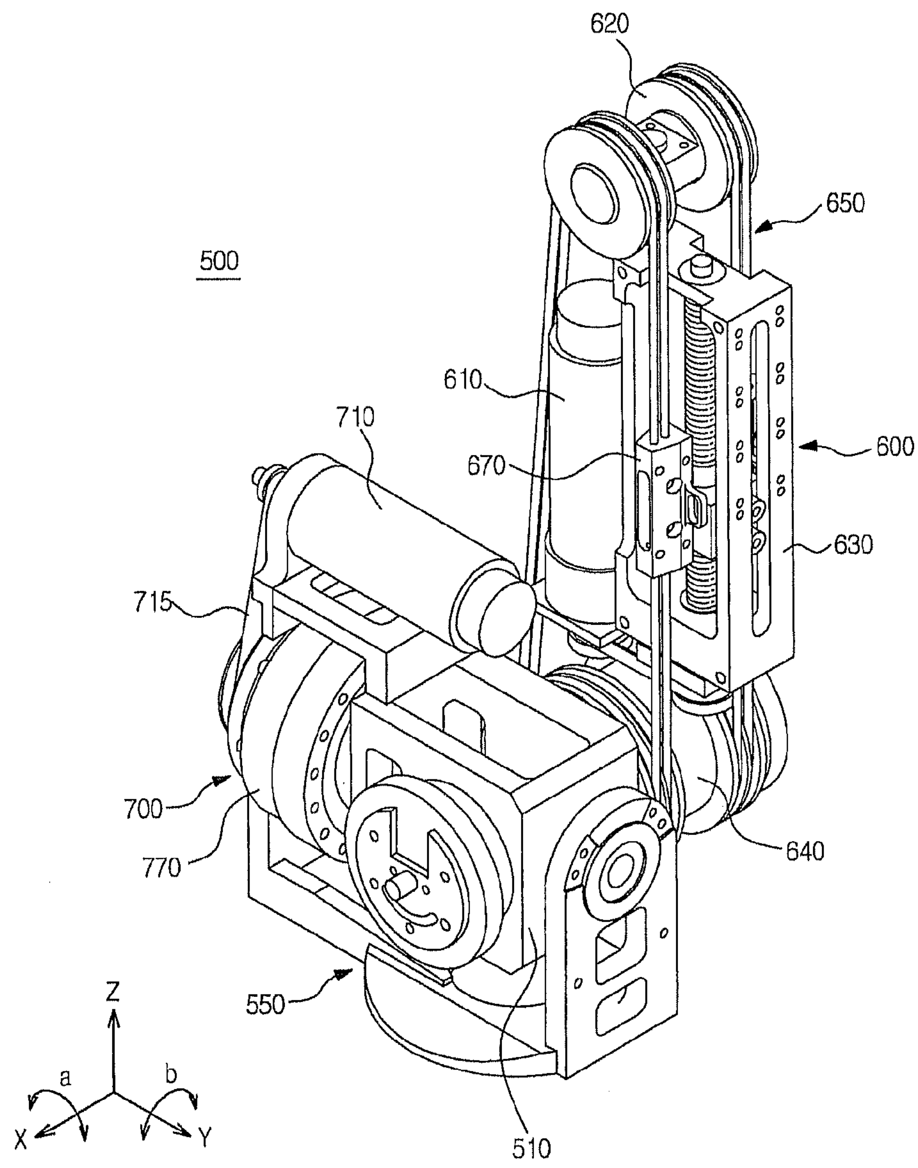


FIG. 3B

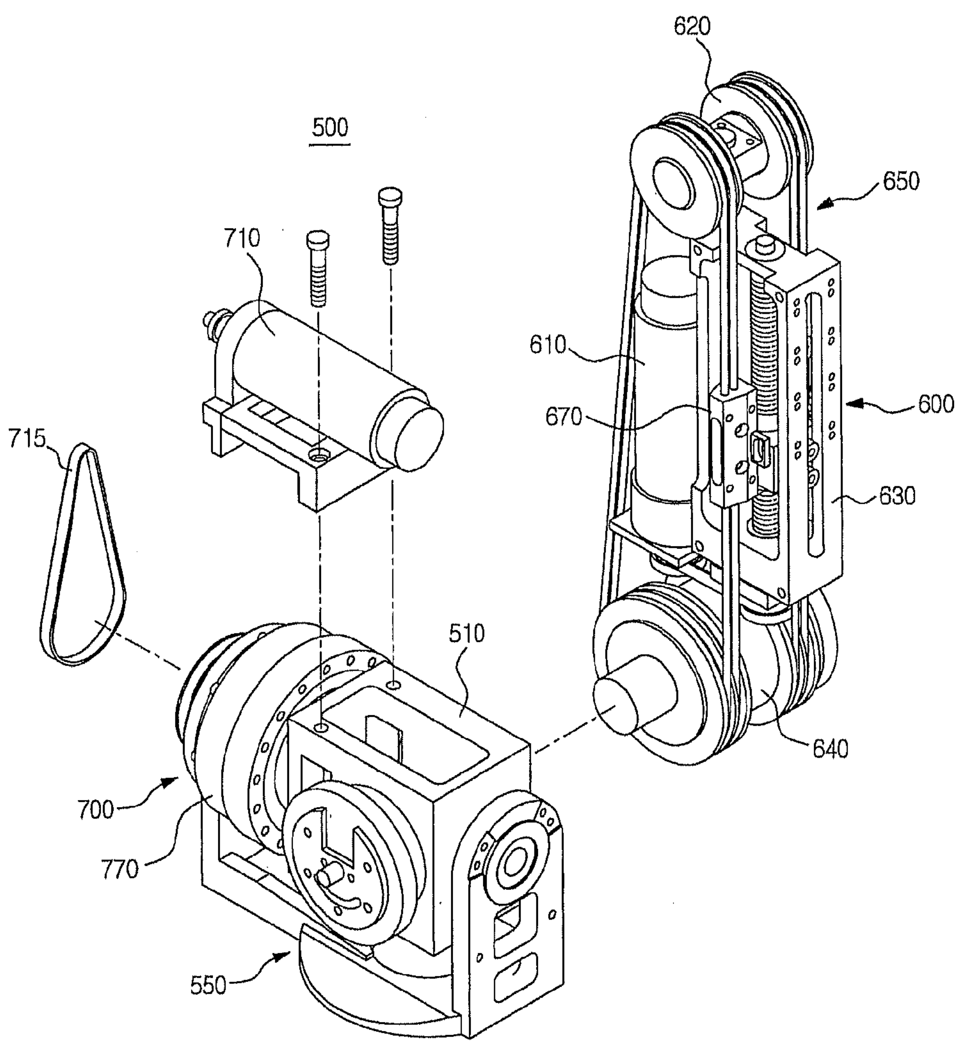


FIG. 3C

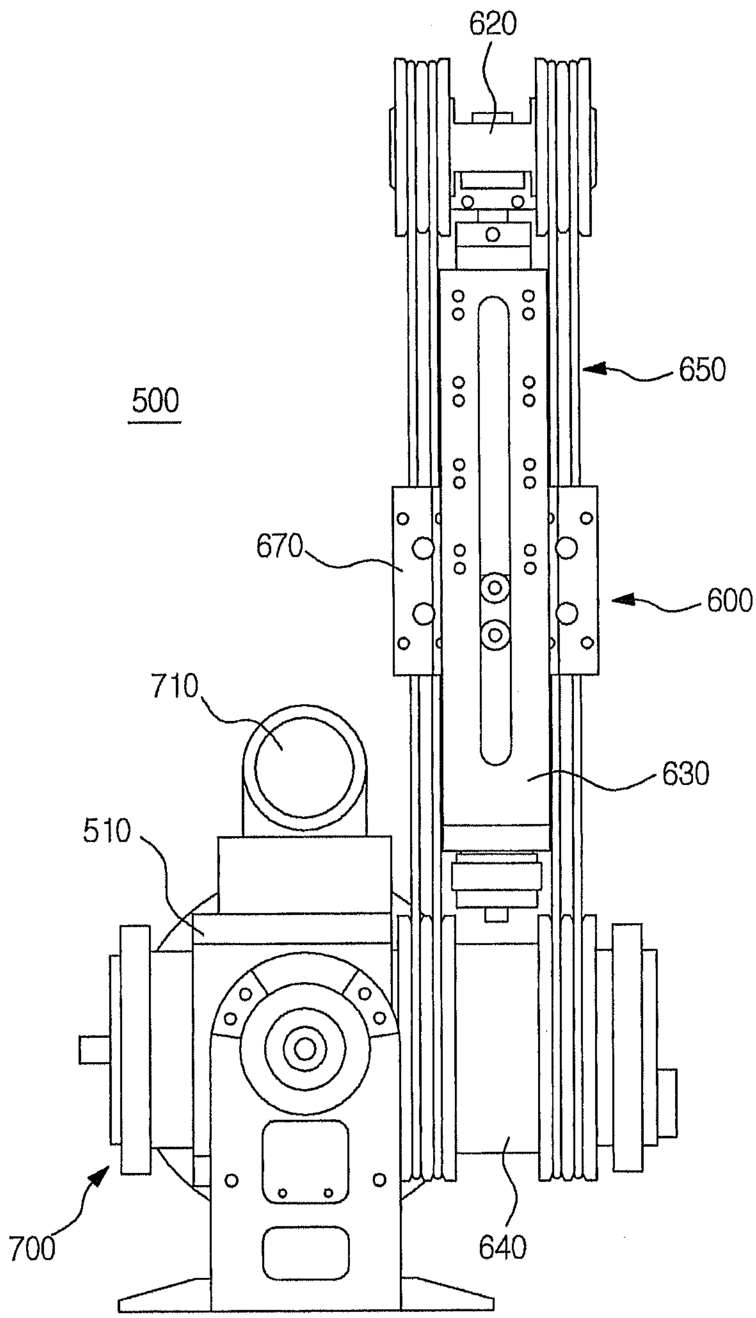


FIG. 3D

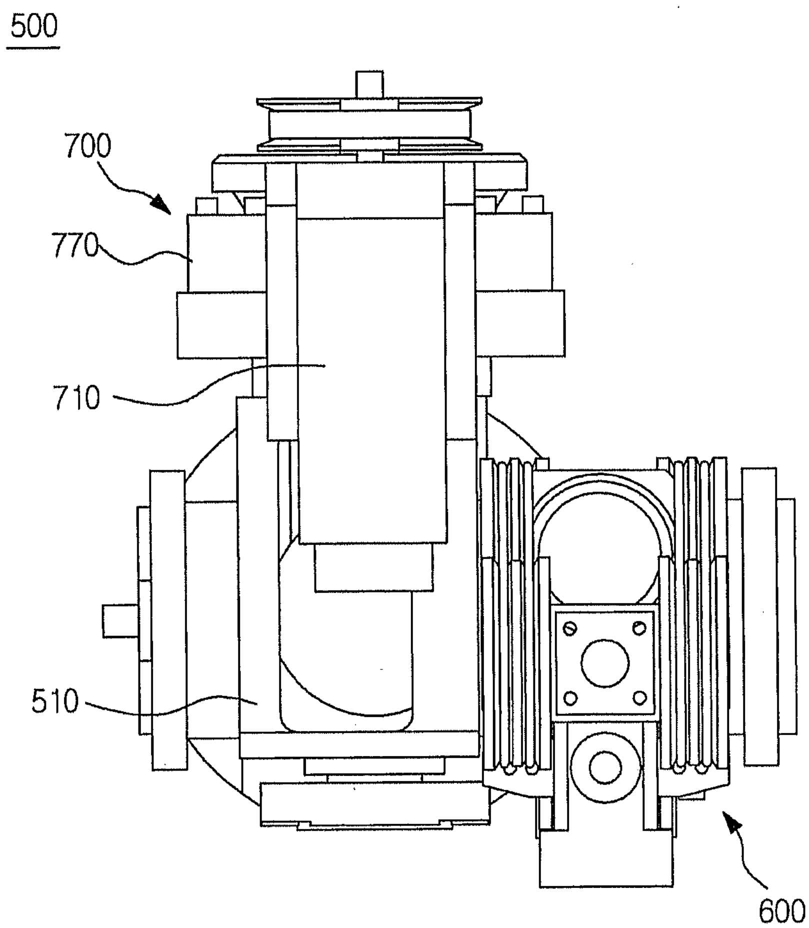


FIG. 3E

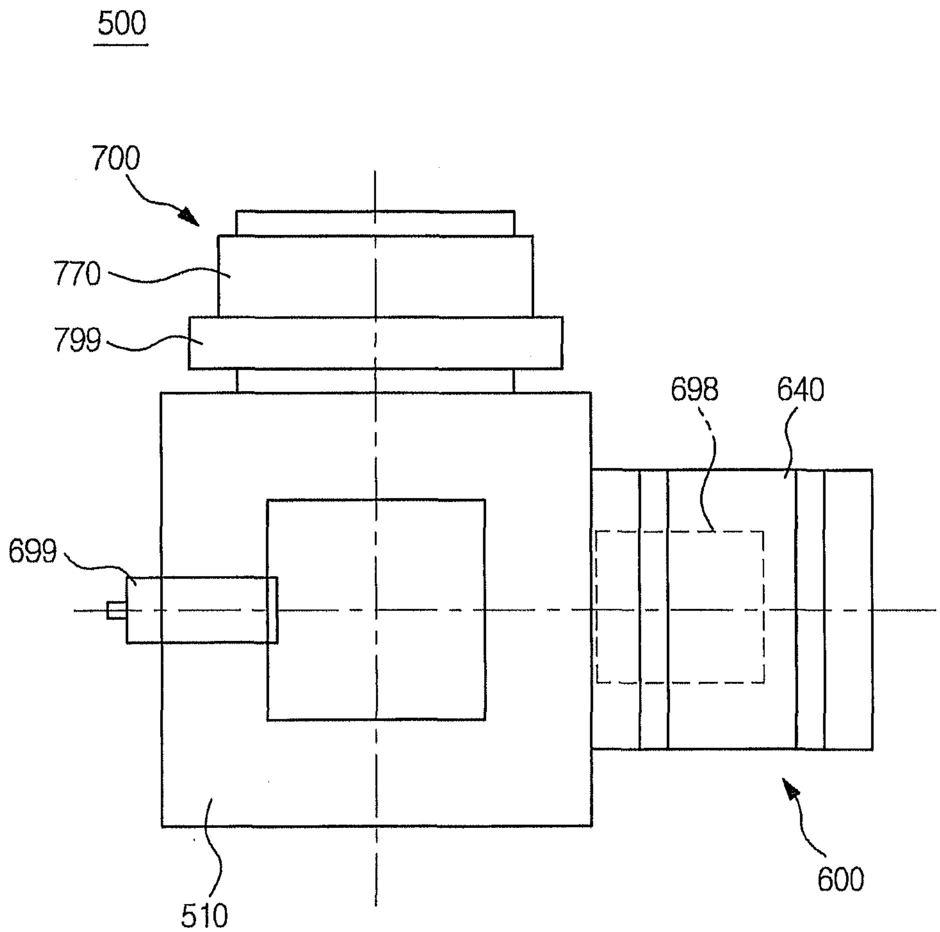
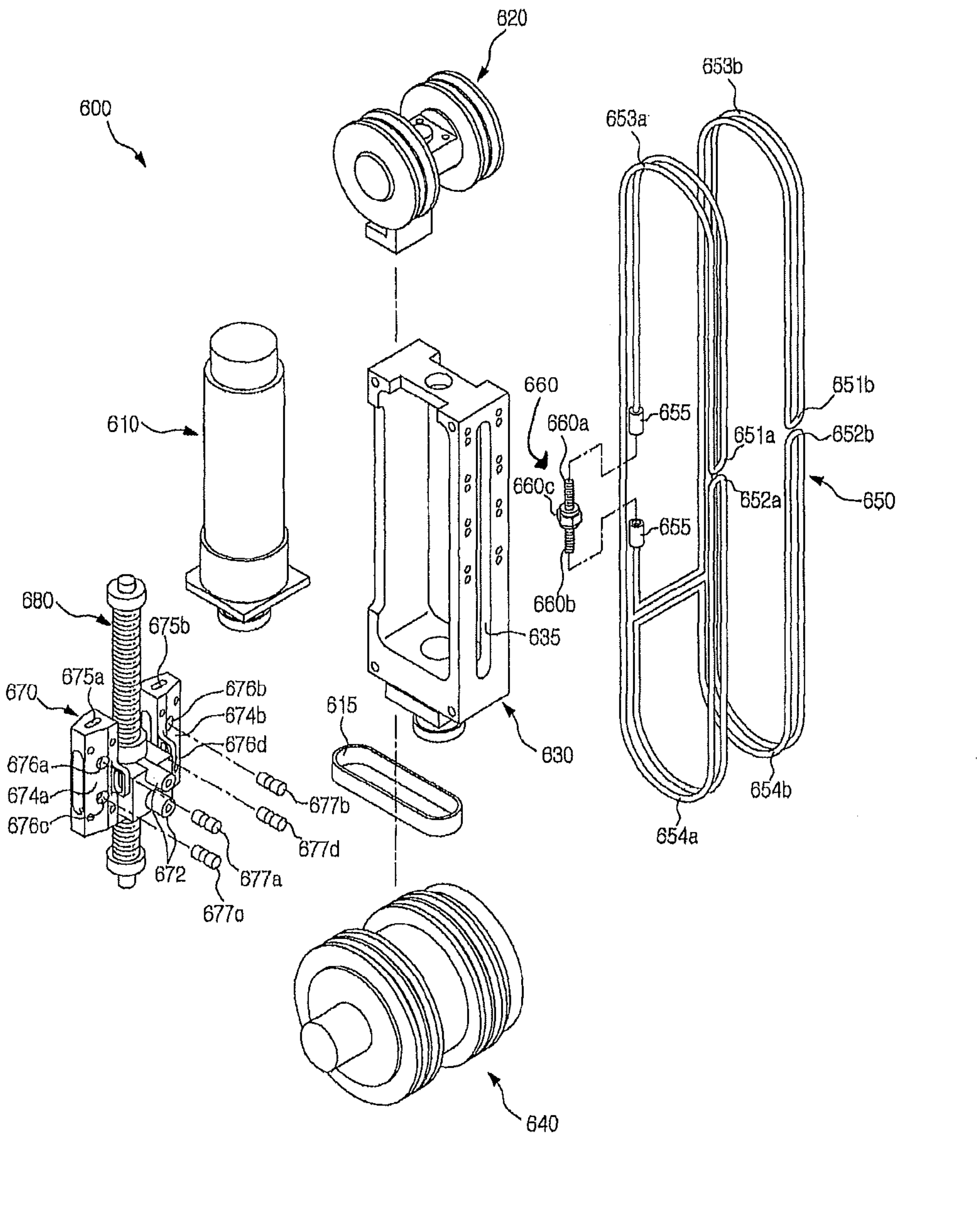


FIG. 4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635
670
675a
676b
674b
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676d
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654b
677d
654a
672
677a
677c
640

FIG. 5

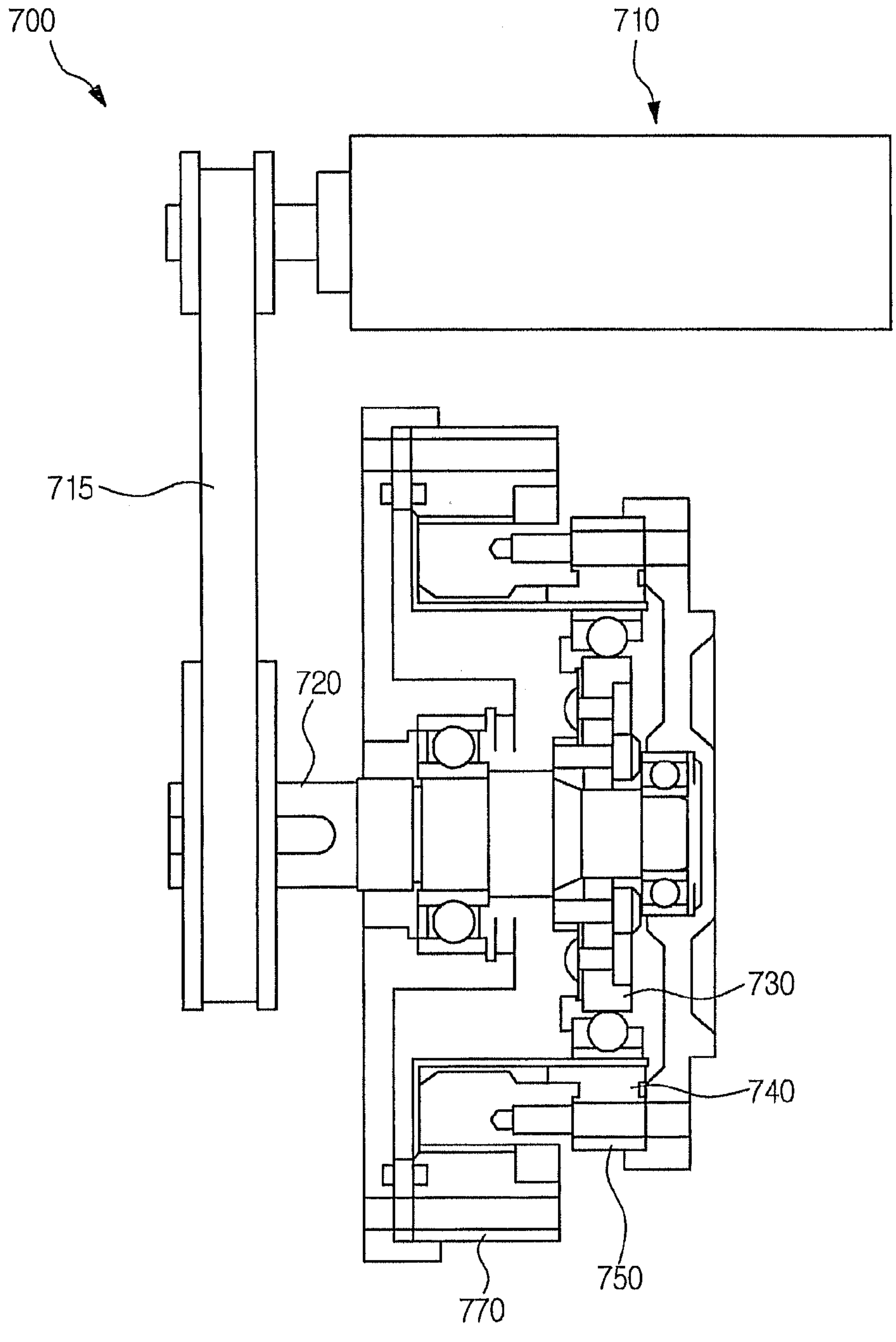
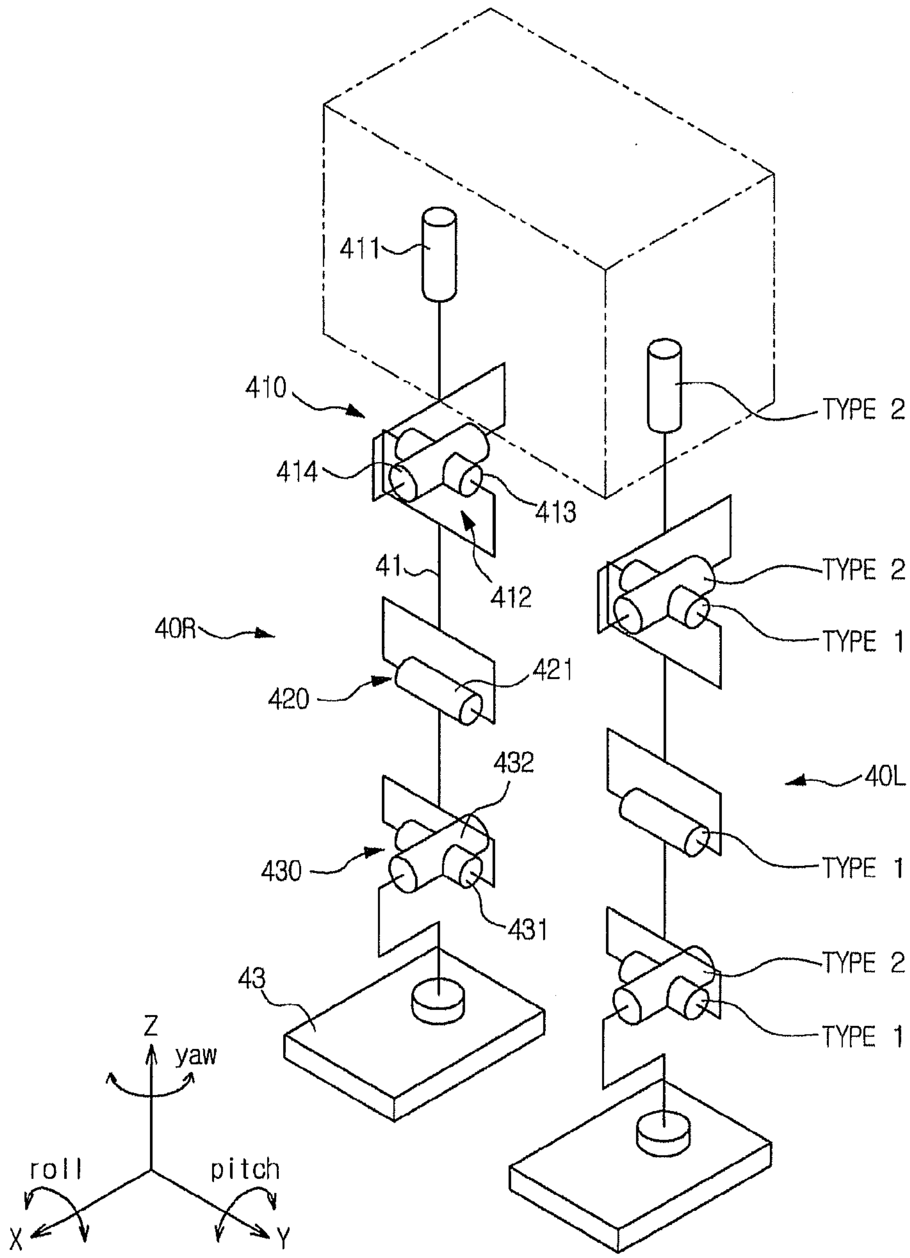


FIG. 6


411
410
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41
40R
420
421
432
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431
43
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TYPE 2
TYPE 1
40L
TYPE 1
TYPE 2
TYPE 1
Z
yaw
roll
pitch
X
Y

FIG. 7A

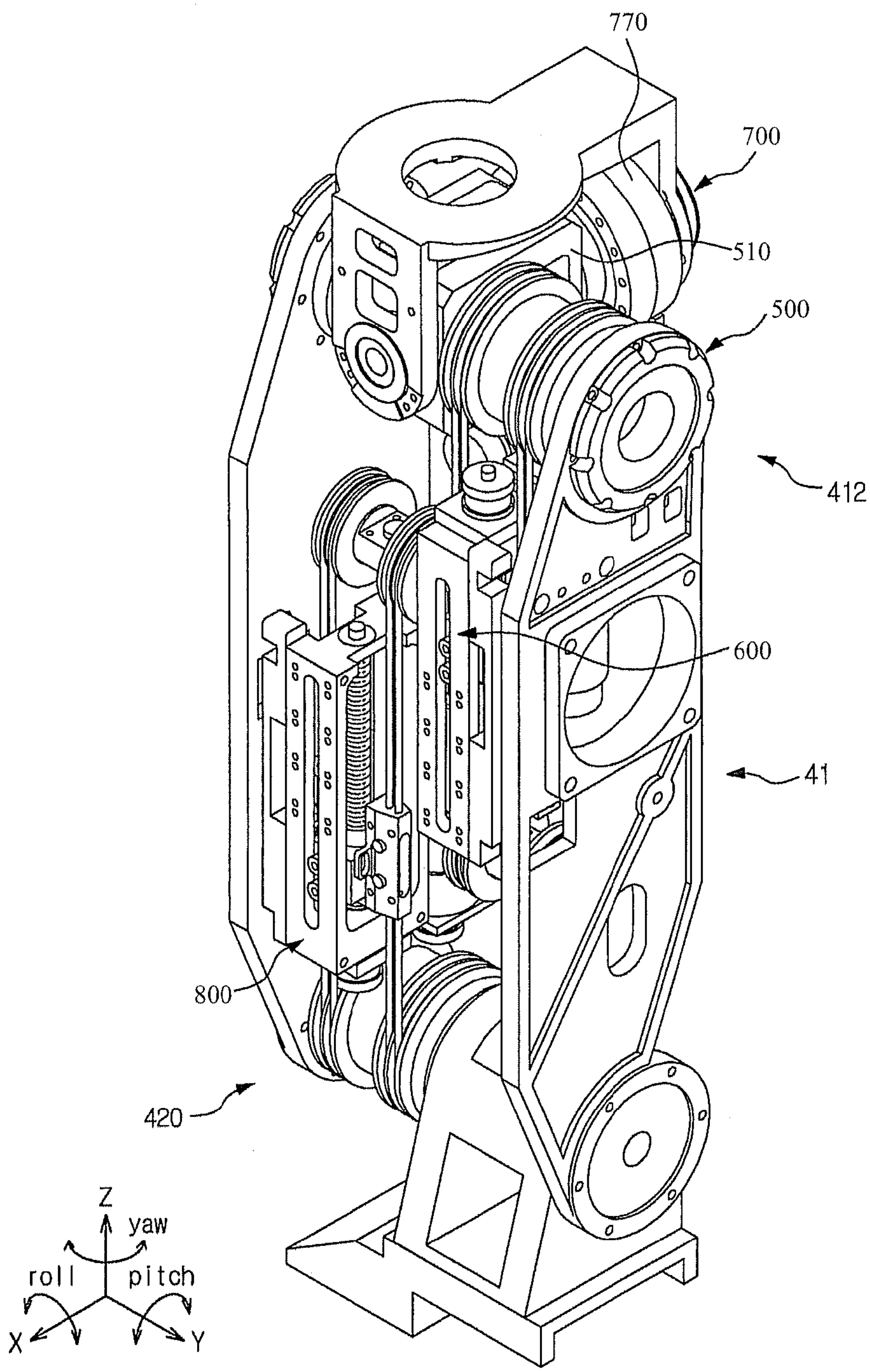


FIG. 7B

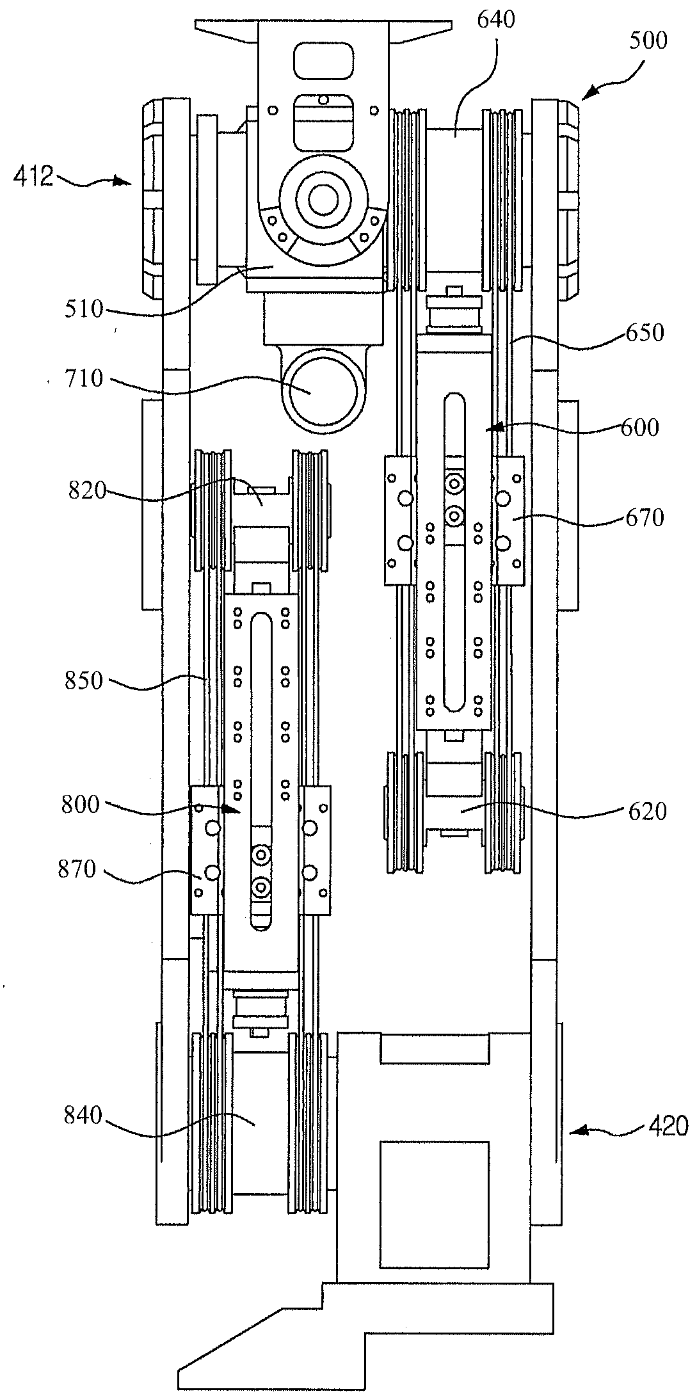
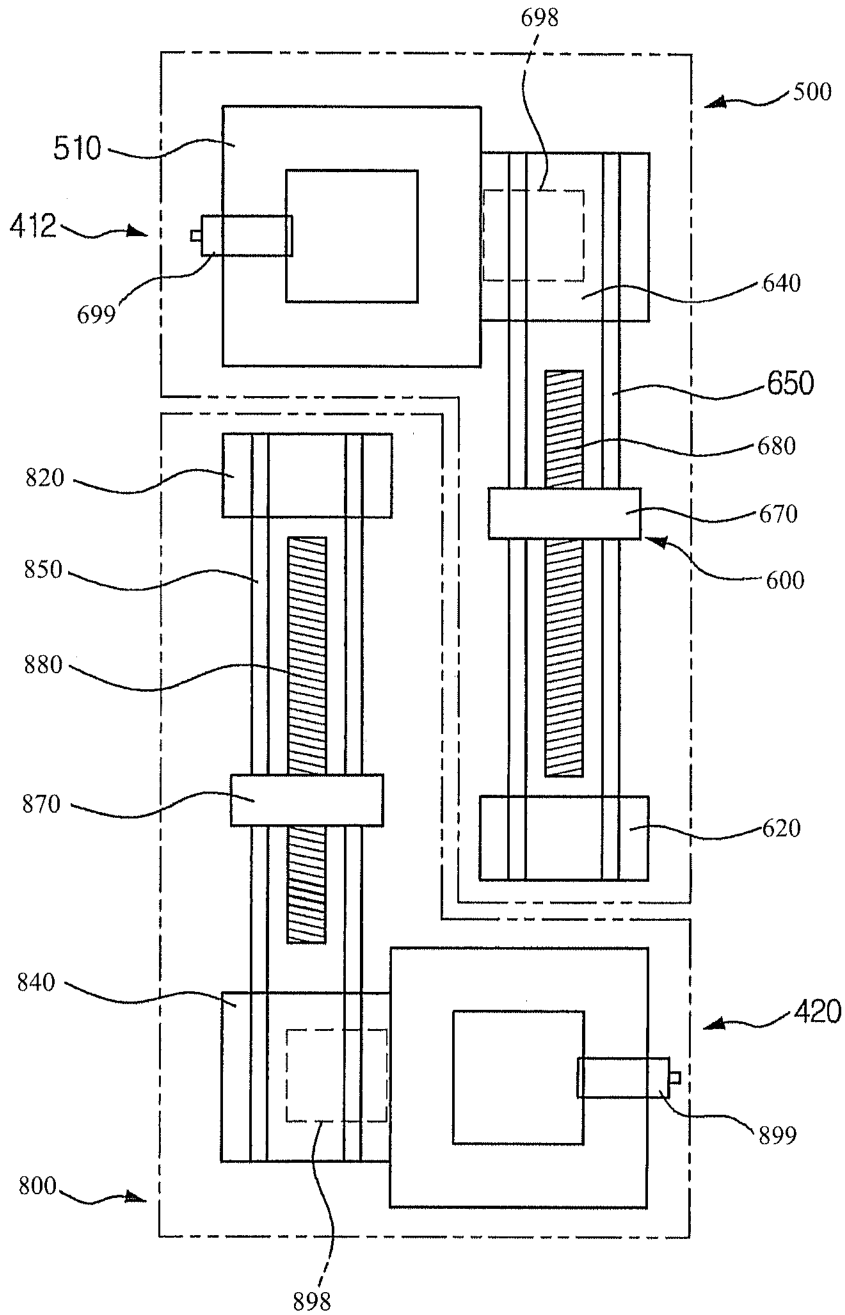


FIG. 7C


698
500
510
412
699
640
650
680
670
600
620
820
850
880
870
840
420
899
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898

ROBOT JOINT DRIVING METHOD, COMPUTER-READABLE MEDIUM, DEVICE ASSEMBLY AND ROBOT HAVING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Patent Application No. 2009-84795, filed on Sep. 9, 2009 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field

Example embodiments relate to a robot using robot joint driving devices of several types.

2. Description of the Related Art

Robots of various types, i.e., bipedal robots and quadrupedal robots, have been developed for household, military, and industrial purposes.

In particular, humanoid robots, which have a similar body structure to that of humans, are manufactured to conduct motions similar to those of humans.

These humanoid robots conduct various motions including walking motions, such as running, walking, etc., through movements of joints, which are similar to those of humans.

Among joint driving methods, a gear reduction method in which a joint is driven using a motor and a decelerator connected to the motor is generally widely used.

The gear reduction method has advantages including providing high rigidity and high precision in motions. However, the gear reduction method has low back-drivability due to high internal friction.

SUMMARY

Therefore, it is one aspect of the example embodiments to provide a robot joint structure which has high rigidity while conducting similar motions to those of humans, and a robot having the same.

It is a further aspect of the example embodiments to provide a robot joint structure in which joint driving units using different driving methods are used in combination, and a robot having the same.

It is another aspect of the example embodiments to provide a robot joint structure in which a joint driving unit is selected in consideration of characteristics of respective joints, and a robot having the same.

The foregoing and/or other aspects are achieved by providing a robot joint driving device assembly including a frame, a first joint driving device provided at one side of the frame to drive a robot joint unit in a first direction, and a second joint driving device provided at another side of the frame to drive the robot joint unit in a second direction perpendicular to the first direction, wherein the first joint driving device drives the robot joint unit using a wire, and the second joint driving device drives the robot joint unit using a gear reduction method.

The first joint driving device may include a first driving motor movable in regular and reverse directions, a movable member rectilinearly moving according to rotation of the first driving motor, a wire unit connected to both sides of the movable member, an idle pulley rotatably provided at one side of the wire unit, a joint part provided at the other side of the wire unit, and an adjustment unit to adjust tension of the wire unit.

The first joint driving device may further include a ball screw part, to which the movable member is screw-connected.

The ball screw part may be connected with the first driving motor and may be rotated according to driving of the first driving motor.

The movable member may include wire connection parts, to which the wire unit may be connected.

Each of the wire connection parts may include wire passage holes, into which the wire unit is inserted, and wire coupling holes to fix the wire unit to the movable member by coupling pins.

The second joint driving device may include a second driving motor, an input shaft connected to the second driving motor, an oval wave generator connected to the input shaft, a flex spline connected with an output part, having teeth formed on some portions thereof, and installed at the outside of the wave generator, and a circular spline having teeth formed therein to receive the flex spline while engaging with the flex spline.

Each of the first joint driving device and the second joint driving device may include a torque sensor to measure torque applied to each robot joint.

The second joint driving device may further include a rotational angle sensor to measure an angle of rotation of a robot joint.

The foregoing and/or other aspects are achieved by providing a robot joint driving device assembly including a frame, a tendon-type joint driving device provided at one side of the frame to drive a robot joint unit in a first direction using a wire, and a harmonic drive-type joint driving device provided at another side of the frame to drive the robot joint unit in a second direction perpendicular to the first direction using a gear reduction method, wherein the tendon-type joint driving device and the harmonic drive-type joint driving device are used in combination to drive the robot joint unit.

The foregoing and/or other aspects are achieved by providing a robot having a plurality of rotary joints including a tendon-type joint driving device to drive at least one of the plurality of rotary joints using a wire, and a harmonic drive-type joint driving device to drive at least one of the plurality of rotary joints using a gear reduction method, wherein the tendon-type joint driving device is used to drive a rotary joint requiring flexible motion, and the harmonic drive-type joint driving device is used to drive a rotary joint requiring high rigidity and high precision.

The tendon-type joint driving device and the harmonic drive-type joint driving device may be used in combination at a hip joint unit. The tendon-type joint driving device may drive the hip joint unit in the pitch direction, and the harmonic drive-type joint driving device may drive the hip joint unit in the roll direction.

The tendon-type joint driving device and the harmonic drive-type joint driving device may be used in combination at an ankle joint unit. The tendon-type joint driving device may drive the ankle joint unit in the pitch direction, and the harmonic drive-type joint driving device may drive the ankle joint unit in the roll direction.

The tendon-type joint driving device may be used to drive a knee joint unit in the pitch direction.

The foregoing and/or other aspects are achieved by providing a method, including driving a robot joint unit a first direction by a first joint driving device provided at one side of a frame, and driving the robot joint unit in a second direction perpendicular to the first direction by a second joint driving device provided at another side of the frame, wherein the first joint driving device drives the robot joint unit using a wire and the second joint driving device drives the robot joint unit using a gear reduction method.

According to another aspect of one or more embodiments, there is provided at least one computer readable medium including computer readable instructions that control at least one processor to implement methods of one or more embodiments.

Additional aspects, features, and/or advantages of embodiments will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a front view illustrating an external appearance of a humanoid robot in accordance with example embodiments;

FIG. **2** is a schematic perspective view illustrating a configuration of the humanoid robot of FIG. **1**;

FIG. **3**A is a perspective view illustrating an external appearance of a robot joint driving device assembly;

FIG. **3**B is an exploded perspective view of the robot joint driving device assembly of FIG. **3**A;

FIG. **3**C is a front view of the robot joint driving device assembly of FIG. **3**A;

FIG. **3**D is a plan view of the robot joint driving device assembly of FIG. **3**A;

FIG. **3**E is a schematic view illustrating a structure of FIG. **3**D;

FIG. **4** is an exploded perspective view of a first joint driving device;

FIG. **5** is a longitudinal-sectional view of a second joint driving device;

FIG. **6** is a schematic view illustrating arrangement of joint driving device assemblies applied to both legs of the robot;

FIG. **7**A is a perspective view illustrating a hip joint unit and a knee joint unit;

FIG. **7**B is a front view of FIG. **7**A; and

FIG. **7**C is a conceptual view simplified from FIG. **7**B.

DETAILED DESCRIPTION

Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. Embodiments are described below to explain the present disclosure by referring to the figures.

FIG. **1** is a front view illustrating an external appearance of a humanoid robot in accordance with example embodiments, and FIG. **2** is a schematic perspective view illustrating a configuration of the humanoid robot of FIG. **1**.

As shown in FIGS. **1** and **2**, a humanoid robot (hereinafter, simply referred to as a 'robot') **1** includes a torso **10**, arms **20**R and **20**L connected to both sides of the upper portion of the torso **10**, a head **30** connected to the upper end of the torso **10**, and legs **40**R and **40**L connected to both sides of the lower portion of the torso **10**. Both arms **20**R and **20**L are respectively connected to the torso **10** through shoulder joint assemblies **210**R and **210**L, and the head **30** is connected to the torso **10** through a neck **50**. Here, R and L respectively represent a right side and a left side.

The inside of the torso **10** is protected by a cover **11**. A control unit **12**, a battery **13**, and an inclination sensor **14** may be installed in the torso **10**. The inclination sensor **14** detects an angle of inclination of the torso **10** relative to a vertical axis and its angular velocity.

The torso **10** is divided into a breast part **10***a* and a waist part **10***b*, and a joint **15** causing the breast part **10***a* to be rotated relative to the waist part **10***b* is installed between the breast part **10***a* and the waist part **10***b*. FIG. **2** briefly illustrates the torso **10** as a torso link.

Both arms **20**R and **20**L respectively include upper arm links **21**, lower arm links **22**, and hands **23**. The upper arm links **21** are connected to the torso **10** through the shoulder joint assemblies **210**. The upper arm links **21** and the lower arm links **22** are connected to each other through elbow joint units **220**, and the lower arm links **22** and the hands **23** are connected to each other through wrist joint units **230**.

The elbow joint units **220** respectively include rotary joints **221** rotated in a pitch direction and rotary joints **222** rotated in a yaw direction, and thus have two degrees of freedom. The wrist joint units **230** include rotary joints **231** rotated in the pitch direction and rotary joints **232** rotated in a roll direction, and thus have two degrees of freedom.

Five fingers **23***a* are installed at each of the hands **23**. Plural joints (not shown), respectively driven by motors, may be installed on each of the fingers **23***a*. The fingers **23***a* perform various motions, such as gripping of an object and indicating of a special direction, in connection with the motion of the arms **20**R and **20**L.

The shoulder joint assemblies **210**R and **210**L are mounted at both sides of the torso **10**, and connect both arms **20**R and **20**L to the torso **10**. The two shoulder joint assemblies **210**R and **210**L are disposed between the torso **10** and the arms **20**R and **20**L of the robot **1**, and allow the arms **20**R and **20**L to move.

Cameras **31** serving as the sense of sight of the robot **1** and microphones **32** serving as the sense of hearing of the robot **1** are connected to the head **30**.

The head **30** is connected to the torso **10** through a neck joint unit **310**. The neck joint unit **310** includes a rotary joint **311** rotated in the yaw direction, a rotary joint **312** rotated in the pitch direction, and a rotary joint **313** rotated in the roll direction, and thus has three degrees of freedom.

Head rotating motors (not shown) are respectively connected to the respective rotary joints **311**, **312**, and **313** of the neck joint unit **310**. The control unit **12** controls the respective motors and thus drives the rotary joints **311**, **312**, and **313** at proper angles, thereby allowing the head **40** to move in a desired direction.

Both legs **40**R and **40**L respectively include thigh links **41**, calf links **42**, and feet **43**. The thigh links **41** are connected to the torso **10** through thigh joint units **410**. The thigh links **41** and the calf links **42** are connected to each other by knee joint units **420**, and the calf links **42** and the feet **43** are connected to each other by ankle joint units **430**.

The thigh joint units **410** respectively have three degrees of freedom. In particular, the thigh joint units **410** respectively include rotary joints **411** rotated in the yaw direction (around the Z-axis), rotary joints **413** rotated in the pitch direction (around the Y-axis), and rotary joints **414** rotated in the roll direction (around the X-axis). Among the thigh joint units **410**, the rotary joints **413** rotated in the pitch direction and the rotary joints **414** rotated in the roll direction may form hip joint units **412**.

The knee joint units **420** respectively include rotary joints **421** rotated in the pitch direction, and thus have one degree of freedom. The ankle joint units **430** respectively include rotary joints **431** rotated in the pitch direction and rotary joints **432** rotated in the roll direction, and thus have two degrees of freedom.

Since the legs **40**R and **40**L respectively include six rotary joints for three joint units **410**, **420**, and **430**, a total of twelve rotary joints is provided for the two legs **40**R and **40**L. Although not shown in the drawings, motors to drive the rotary joints are respectively installed on the legs **40**R and **40**L. The control unit **12** properly controls the motors provided on the legs **40**R and **40**L, thereby achieving various motions of the legs **40**R and **40**L including walking of the robot **1**.

Multi-axis force and torque (F/T) sensors **44** are respectively installed between the feet **43** and the ankle joint units **430** of the two legs **40**R and **40**L. The multi-axis F/T sensors **44** measure three directional components (Mx, My, Mz) of moment and three directional components (Fx, Fy, Fz) of force transmitted from the feet **43**, and detect whether or not the feet **43** are planted on the ground or loads are applied to the feet **43**.

Hereinafter, a robot joint driving device assembly **500** used in at least one of the several joint units of the robot will be described.

FIG. **3**A is a perspective view illustrating an external appearance of the robot joint driving device assembly. FIG. **3**B is an exploded perspective view of the robot joint driving device assembly of FIG. **3**A. FIG. **3**C is a front view of the robot joint driving device assembly of FIG. **3**A. FIG. **3**D is a plan view of the robot joint driving device of FIG. **3**A. FIG. **3**E is a schematic view illustrating a structure of FIG. **3**D. FIG. **4** is an exploded perspective view of a first joint driving device. FIG. **5** is a longitudinal-sectional view of a second joint driving device.

As shown in FIGS. **3**A to **3**E, the robot joint driving device assembly **500** includes a frame **510**, a first joint driving device **600** provided at one side of the frame **510** to drive a robot joint part **550** in a first direction (a), and a second joint driving device **700** provided at the other side of the frame **510** to drive the robot joint part **550** in a second direction (b) perpendicular to the first direction (a).

The robot joint driving device assembly **500** rotatably drives the robot joint part **550** in two directions, i.e. the first direction (a) and the second direction (b). The first joint driving device **600** controls the driving of the robot joint part **550** in the first direction (a), and the second joint driving device **700** controls the driving of the robot joint part **550** in the second direction (b).

A detailed description of the first joint driving device **600** and the second joint driving device **700** will be given later.

As shown in FIG. **3**E, a first torque sensor **698** to measure torque transmitted to a robot joint part **640** in the first direction (a) is installed in the robot joint part **640** of the first joint driving device **600**. Further, a rotational angle sensor **699** to measure a degree of rotation of the robot joint part **640** in the first direction (a) is installed in the frame **510** opposite to the robot joint part **640**.

A second torque sensor **799** to measure torque transmitted to an output part **770** of the second joint driving device **700** in the second direction (b) is installed between the second joint driving device **700** and the frame **510**.

With reference to FIG. **4**, the first joint driving device **600** includes a first driving motor **610** moving in regular and reverse directions, a ball screw part **680** connected with the first driving motor **610** and rotated, a movable member **670** rectilinearly moving according to rotation of the ball screw part **680**, a wire unit **650** connected with both sides of the movable member **670**, an idle pulley **620** rotatably disposed at a designated side of the wire unit **650**, the robot joint part **640** rotatably arranged at the other side of the wire unit **650**, and an adjustment unit **660** to adjust tension of the wire unit **650**.

The first driving motor **610** moves in regular and reverse directions, and is attached to one side of a guide frame **630**. The first driving motor **610** is connected to the ball screw part **680** by a belt **615**, and transmits rotary force to the ball screw part **680** by the belt **615**.

The ball screw part **680** serves to transmit the rotary force of the first driving motor **610** to the movable member **670**, and is screw-connected with the movable member **670**.

The movable member **670** rectilinearly moves up and down, and serves to transmit the force of the first driving motor **610** to the wire unit **650**.

The movable member **670** includes wire connection parts **674***a* and **674***b* formed at both sides thereof such that the wire unit **650** is connected to the wire connection parts **674***a* and **674***b*. The wire connection parts **674***a* and **674***b* include wire passage holes **675***a* and **675***b*, into which the wire unit **650** is inserted, and wire coupling holes **676***a*, **676***b*, **676***c*, and **676***d*, to which the wire unit **650** is fixed by coupling pins **677***a*, **677***b*, **677***c*, and **677***d*.

The wire unit **650** inserted into the wire passage holes **675***a* and **675***b* is fixed to the movable member **670** by the coupling pins **677***a*, **677***b*, **677***c*, and **677***d* connected to the wire coupling holes **676***a*, **676***b*, **676***c*, and **676***c*.

That is, first ends **651***a* and **651***b* of the wire unit **650** at one side are inserted into the wire passage holes **675***a* and **675***b* formed on the upper portion of the movable member **670** and are fixed to the movable member **670** by coupling the coupling pins **677***a* and **677***b* with the upper wire coupling holes **676***a* and **676***b*, and second ends **652***a* and **652***b* of the wire unit **650** at the other side are inserted into the wire passage holes (not shown) formed on the lower portion of the movable member **670** and are fixed to the movable member **670** by coupling the coupling pins **677***c* and **677***d* with the lower wire coupling holes **676***c* and **676***d*.

Movable member guides **672** protrude forward from the front surface of the central portion of the movable member **670**. The movable member guides **672** serve to induce up and down rectilinear motion of the movable member **670**, are inserted into a guide rail **635** formed at the central portion of the guide frame **630** and move up and down along the guide rail **635**.

The wire unit **650** is connected to the idle pulley **620** and the robot joint part **640** while maintaining a designated tension. The wire unit **650** is preferably made of steel, and surrounds the disc-shaped idle pulley **620** and robot joint part **640**.

The wire unit **650** is connected to the adjustment unit **660** to maintain a designated tension. The adjustment unit **660** includes a right-hand thread part **660***a* at one end thereof, and a left-hand thread part **660***b* at the other end thereof. The right-hand thread part **660***a* and the left-hand thread part **660***b* are received in female screws **655** provided on the wire unit **650**.

The right-hand thread **660***a* and the left-hand thread **660***b* of the adjustment unit **660** are rotated in a clockwise direction or a counterclockwise direction by an adjustment part **660***c*, and the tension of the wire unit **650** may be adjusted by varying the relative length of the wires **650** surrounding the idle pulley **620** and the robot joint part **640** according to the rotation of the right-hand thread **660***a* or the left-hand thread **660***b*.

The wire unit **650** may be assembled such that two pairs of strands, i.e., a total of four strands, are arranged when the wire unit **650** is connected to the right-hand thread part **660***a* and the left-hand thread part **660***b* of the adjustment unit **660**. Further, the wire unit **650** is installed to surround the upper portion of the circumference of the idle pulley **620** and the lower portion of the circumference of the robot joint part **640**.

Portions **654***a* and **654***b* of the wire unit **650** are wound on the robot joint part **640** so that the robot joint part **640** receives driving force transmitted from the first driving motor **610**. Other portions **653***a* and **653***b* of the wire unit **650** are wound on the idle pulley **620** separately installed to adjust the tension of the wire unit **650**.

The above first joint driving device **600** is a joint driving device which drives the robot joint part **640** using the wire unit **650**, i.e., a tendon-type joint driving device.

The tendon-type joint driving device has excellent back-drivability, and thus achieves safe and flexible driving of a joint. That is, the tendon-type joint driving device has excellent back-drivability and assures flexible motion.

With reference to FIG. **5**, the second joint driving device **700** includes a second driving motor **710** provided movably in regular and reverse directions, an input shaft **720** connected to the second driving motor **710**, an oval wave generator **730** connected to the input shaft **720**, a flex spline **740** connected with an output part **770**, having teeth formed on some portions thereof, and installed at the outside of the wave generator **730**, and a circular spline **750** having teeth formed therein to receive the flex spline **740** while engaging with the flex spline **740**. Reference numeral **715** is a belt connecting the second driving motor **710** and the input shaft **720**. Rotary force of the second driving motor **710** is transmitted to the output part **770** in a decelerated state via the input shaft **720**, the wave generator **730**, the flex spline **740**, and the circular spline **750**, and the output part **770** is rotated as one of robot joint units.

The second joint driving device **700** is a conventional harmonic drive-type joint driving device using a gear reduction method, and a detailed description thereof will be omitted.

The above second joint driving device **700** has a small size and high rigidity, and achieves fine motion.

As described above, the first joint driving device **600** has excellent back-drivability and achieves safe and flexible joint motion, and the second joint driving device **700** has high rigidity and achieves fine joint motion.

Therefore, purposes and required motions of respective joint units of the robot **1** are analyzed, and the robot joint driving device assembly **500** is arranged such that a joint requiring high back-drivability is driven by the tendon-type first joint driving device **600**, and a joint requiring fine motion and high rigidity is driven by the harmonic drive-type second joint driving device **700**.

A joint requiring high back-drivability is arranged in the first direction (a) in which the first joint driving device **600** is driven, and a joint requiring fine motion and high rigidity is arranged in the second direction (b) in which the second joint driving device **700** is driven.

FIG. **6** is a schematic view illustrating arrangement of joint driving device assemblies applied to both legs of the robot.

Detailed arrangement of joint driving devices at both legs **40**R and **40**L of the robot **1** is shown in FIG. **6**. In FIG. **6**, "TYPE **1**" denotes the tendon-type first joint driving device **600**, and "TYPE **2**" denotes the harmonic drive-type second joint driving device **700**.

The rotary joint **413** rotated in the pitch direction (around the Y-axis) and the rotary joint **414** rotated in the roll direction (around the X-axis) of the hip joint unit **412** are driven by the above-described robot joint driving device assembly **500**, the rotary joint **431** rotated in the pitch direction (around the Y-axis) and the rotary joint **432** rotated in the roll direction (around the X-axis) of the ankle joint unit **430** are driven by the above-described robot joint driving device assembly **500**, the rotary joint **411** rotated in the yaw direction (around the Z-axis) is driven by the conventional harmonic drive-type joint driving device, and the rotary joint **421** of the knee joint unit **420** is driven by the first joint driving device **600**.

Hereinafter, driving structures of the hip joint unit **412** and the knee joint unit **420** will be described.

FIG. **7**A is a perspective view illustrating the hip joint unit and the knee joint unit, FIG. **7**B is a front view of FIG. **7**A, and FIG. **7**C is a conceptual view simplified from FIG. **7**B.

As shown in FIG. **7**A to **7**C, a hip joint unit driving device assembly **500** to drive the hip joint unit **412** and a knee joint unit driving device **800** to drive the knee joint unit **420** are arranged on the thigh link **41**.

The hip joint unit driving device assembly **500** drives the hip joint unit **412** in two directions, i.e., the roll direction and the pitch direction. The hip joint unit driving device assembly **500** includes a frame **510**, a tendon-type joint driving device **600** provided at one side of the frame **510** to rotate the hip joint unit **412** in the pitch direction, and a harmonic drive-type joint driving device **700** provided at the other side of the frame **510** to rotate the hip joint unit **412** in the roll direction.

The hip joint unit driving device assembly **500** utilizes the structure of the robot joint driving device assembly **500** shown in FIGS. **3**A to **5**. In the hip joint unit driving device assembly **500**, the tendon-type joint driving device **600** provided at one side of the frame **510** rotates the hip joint unit **412** in the pitch direction, and the harmonic drive-type joint driving device **700** provided at the other side of the frame **510** rotates the hip joint unit **412** in the roll direction.

The knee joint unit driving device **800** utilizes the structure of the first joint driving device **600** of the robot joint driving device assembly **500** shown in FIGS. **3**A to **5**, and rotates the knee joint unit **420** in the pitch direction.

In the same manner as the first joint driving device **600**, the hip joint unit driving device assembly **500** and the knee joint unit driving device **800** respectively include movable members **670** and **870**, wires **650** and **850**, idle pulleys **620** and **820**, and joint parts **640** and **840**.

Here, the hip joint unit driving device assembly **500** and the knee joint unit driving device **800** are arranged in one thigh link **41**.

In the same manner as the first joint driving device **600**, the hip joint unit driving device assembly **500** and the knee joint unit driving device **800** respectively further include torque sensors **698** and **898** to measure torques transmitted to the hip joint unit **412** and the knee joint unit **420** in the pitch direction, and a rotational angle sensor including **699** and **899** to measure angles of rotation of the hip joint unit **412** and the knee joint unit **420** in the pitch direction.

Hereinafter, a joint driving motion of the robot **1** in accordance with example embodiments will be described.

If the robot **1** wants to move respective joints, and robot **1** transmits a signal to respective joint driving devices through the control unit **12**. For example, if the signal is transmitted to the hip joint unit **412**, there will be a joint driving motion of the robot **1**, which is further described below.

If the robot **1** wants to move the hip joint unit **412** in the pitch direction, the control unit **12** transmits a driving signal to a first driving motor (not shown) of the hip joint unit driving device assembly **500**. When the first driving motor is rotated, rotary force of the first driving motor is transmitted to the movable member **670** via the ball screw part **680**, and rectilinear motion of the movable member **670** rotates the hip joint part **640** in the pitch direction. In order to return the hip joint part **640** to its original state, the first driving motor is rotated in the reverse direction.

If the robot **1** wants to move the hip joint unit **412** in the roll direction, the control unit **12** transmits a driving signal to a second driving motor **710** of the hip joint unit driving device assembly **500**. With reference to FIG. **5**, when the second driving motor **710** is rotated, rotary force of the second driving motor **710** is transmitted to an output part **770** in a gear reduction method via a wave generator, a flex spline, and a circular spline. The rotation of the output part **770** results in rotation of the hip joint part **640** in the roll direction. In order to return the hip joint part **640** to its original state, the second driving motor **710** is rotated in the reverse direction.

Also in the knee joint unit **420** and other joint units, when the control unit **12** transmits a driving signal to respective driving motors, the respective driving devices are operated to move the corresponding joint units in desired directions.

As described above, the robot joint driving device assembly **500** and the robot **1** having the same, the tendon-type joint driving device and the harmonic drive-type joint driving device are properly arranged according to required motions and characteristics of respective joints, thereby assisting the robot **1** to conduct similar motions to those of humans.

Although the example embodiments describe the humanoid robot, the example embodiments may be applied to robots of other various types.

As is apparent from the above description, in a robot joint structure and a robot having the same in accordance with example embodiments, joint driving units are properly arranged according to motion characteristics of respective joints, thereby assisting the robot to conduct similar motions to those of humans.

Further, the robot has high rigidity and high precision.

The above-described embodiments may be recorded in computer-readable media including program instructions to implement various operations embodied by a computer. The media may also include, alone or in combination with the program instructions, data files, data structures, and the like, Examples of computer-readable media (computer-readable storage devices) include magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD ROM disks and DVDs; magneto-optical media such as optical disks; and hardware devices that are specially configured to store and perform program instructions, such as read-only memory (ROM), random access memory (RAM), flash memory, and the like. The computer-readable media may be a plurality of computer-readable storage devices in a distributed network, so that the program instructions are stored in the plurality of computer-readable storage devices and executed in a distributed fashion. The program instructions may be executed by one or more processors or processing devices. The computer-readable media may also be embodied in at least one application specific integrated circuit (ASIC) or Field Programmable Gate Array (FPGA). Examples of program instructions include both machine code, such as produced by a compiler, and files containing higher level code that may be executed by the computer using an interpreter. The described hardware devices may be configured to act as one or more software modules in order to perform the operations of the above-described exemplary embodiments, or vice versa.

Although example embodiments have been shown and described, it should be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the disclosure, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A robot joint driving device assembly, comprising:

a frame;

a first joint driving device provided at one outer side of the frame to drive a robot joint unit in a first direction; and

a second joint driving device provided at another outer side of the frame to drive the robot joint unit in a second direction perpendicular to the first direction,

wherein the first joint driving device includes: a first driving motor movable in regular and reverse directions; a movable member moving rectilinearly according to rotation of the first driving motor by a belt, the movable member including at least one wire connection part, to which a wire unit is connected; the wire unit connected to both sides of the movable member; an idle pulley rotatably provided at one side of the wire unit; and a joint part provided at another side of the wire unit, and

wherein the at least one wire connection part includes at least one wire passage hole, into which the wire unit is inserted, and at least one wire coupling hole to fix the wire unit to the movable member by at least one coupling pin.

2. The robot joint driving device assembly according to claim **1**, wherein the first joint driving device further includes:

an adjustment unit to adjust tension of the wire unit.

3. The robot joint driving device assembly according to claim **1**, wherein the first joint driving device further includes a ball screw part, to which the movable member is screw-connected, the ball screw part receiving rotary force from the belt connected to the first driving motor.

4. The robot joint driving device assembly according to claim **3**, wherein the ball screw part is connected with the first driving motor and is rotated according to driving of the first driving motor.

5. The robot joint driving device assembly according to claim **1**, wherein the second joint driving device includes:

a second driving motor;

an input shaft connected to the second driving motor;

an oval wave generator connected to the input shaft;

a flex spline connected with an output part, having teeth formed on some portions thereof, and installed at an outside of the wave generator; and

a circular spline having teeth formed therein to receive the flex spline while engaging with the flex spline.

6. The robot joint driving device assembly according to claim **5**, wherein the second joint driving device further includes a rotational angle sensor to measure an angle of rotation of a robot joint.

7. The robot joint driving device assembly according to claim **1**, wherein each of the first joint driving device and the second joint driving device includes a torque sensor to measure torque applied to each robot joint.

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